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ABSTRACT

Drawing upon research from a number of fields, this paper explores parallels between new paradigms in the sciences--particularly physics, chemistry, and biology--and new paradigms in reading and literary theory--particularly a socio- or psycholinguistic, semiotic, transactional view of reading and a transactional view of the literary experience. Among the major parallels emphasized in the paper are the following concepts: (1) reality is fundamentally an organic process; (2) there is no sharp separation between observer and what is observed, reader and text, and reader/text and content; (3) the whole (universe, sentence, text, and so forth) is not merely the sum of "parts" that can be separately identified; and (4) meaning is determined through transactions between observer and observed, reader and text, reader/text and context, and among textual elements on and across various levels. (Author/FL)

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Parallels Between New Paradigms in Science and in Reading and Literary Theories

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Abstract

This essay explores parallels between new paradigms in the sciences, particularly quantum physics, chemistry, and biology, and new paradigms in reading and literary theory, particularly a socio-psycholinguistic, semiotic, transactional view of reading and a transactional view of the literary experience. Among the major parallels emphasized are the following concepts: reality is fundamentally an organic process; there is no sharp separation between observer and observed, reader and text, reader/text and context; the whole (universe, sentence, text, etc.) is not merely the sum of "parts" which can be separately identified; meaning is determined through transactions between observer and observed, reader and text, reader/text and context, and among textual elements on and across various levels.

PARALLELS BETWEEN NEW PARADIGMS IN SCIENCE AND IN READING AND LITERARY THEORIES

Alvin Toffler (1980) calls it the "third wave," this new civilization he sees emerging. Physicist Fritjov Capra (1982) also suggests that the underlying values and assumptions that have dominated Western civilization for the last three centuries have begun to change, that individually and collectively we have begun a cultural revolution destined to radically affect our lives in the twenty-first century (1982, pp. 21-49).

Certain aspects of this cultural revolution can of course be traced back not only to earlier thinkers of this and the immediately preceding centuries, like Whitehead and Bergson, Hegel and Kant, but even to the classical Greeks and beyond. Without engaging in lengthy historical review, suffice it to say that today, the evolving shift in perspective can be seen most clearly in the sciences and allied disciplines, where the current shift from a mechanistic to an organic paradigm began at least as early as the late 1920s, with the rise of the Copenhagen school of quantum physics.

In the late 1970s and 1980s this reemerging paradigm has spread to a number of disciplines, most notably chemistry and biology. True, most scientists today are not involved in developing new theories or paradigms (Kuhn 1962, p. 33); rather, they are engaged mainly in experimental research, with little consideration for the broader implications of their work. Entrenched in a world view that has served them well, they may actually oppose the current shift in perspective. Nevertheless, many of those at the leading edge of thought, in some cases Nobel prize winners, are actively

engaged in characterizing the new paradigm that is evolving from experimental research, and are attempting to come to grips with its implications. As the paradigm spreads within various disciplines, it will, of course, affect subsequent theory and research.

There are several tenets that seem basic to the emerging paradigm, including the following:

1. The universe is not fundamentally a mechanism, but an organism.
2. The basic nature of reality is process.
3. One of the most basic processes is transaction, through which entities are endlessly defined and redefined.
4. As a result of transactions, reality consists of events in space-time, not of separately identifiable "things."
5. There is no sharp division between "observer" and "observed," between "self" and "other."
6. The whole is not merely the sum of separately identifiable parts.
7. Cause and effect are often inseparable because events are characterized as much by simultaneity and synchronicity as by linearity.
8. Inorganic and organic matter exist at varying levels of complexity, with lower levels or systems affecting higher levels, and higher affecting lower.
9. Thus there is interrelationship and transaction horizontally, among units (systems) on the same level, and vertically, among the various levels (systems) themselves.

10. Thus, our "commonsense" notions of the universe are seriously in error, based as they are upon inadequate data (see "Commonsense as a Cultural System" in Geertz 1983).

In discussing the emergence of some of these concepts in modern science and demonstrating how they are reflected in current reading and literary theory, I aim not so much to offer new insights into language and language processing as to illuminate for scholars of language and literature some of the parallels between physics, chemistry, biology, and that unique kind of intellectual functioning we call language,

In the following pages, what I propose to do is discuss some of the research that has led to the new paradigm in subatomic physics, then discuss concepts and theories from chemistry and biology. After sketching some of these ideas, I will return to reading and literary theory, discussing some of the parallels between these disciplines and the scientific disciplines discussed. Finally, I will summarize some of these parallels and then return briefly to a discussion of the larger emerging paradigm of which science and reading and literary theory are a part.

For an introduction to research and theory in the revolutionary discipline of quantum physics, I would particularly recommend Gary Zukav's The Dancing Wu Li Masters (1979). For an overview of emerging theories and concepts from various disciplines, I would recommend Fritjov Capra's The Turning Point (1982).

The "New" Paradigm Emerging from the Sciences

Quantum Physics

Though the mechanistic paradigm still dominates our "commonsense" view of reality, modern subatomic physics has demonstrated the limitations of this paradigm. This shift in perspective, the recent shift to an organic rather than a mechanistic paradigm, began shortly after the turn of this century. Nearly a century before that, in 1803, Thomas Young had confirmed the hypothesis of Newton's contemporary, Huygens, that light has the properties of a wave. Then in 1905, Albert Einstein proved the essential validity of Newton's own theory of light, by demonstrating that light has the properties of a particle. Since no one has been able to disprove either conclusion, we are left with a paradox: light is both a wave and a particle. As Zukav (1979) observes, "The wave-particle duality marked the end of the 'Either-Or' way of looking at the world," at least for quantum physicists (p. 65). (See also Diesing (1971) for a discussion of the non-dualistic nature of holistic research in the social sciences.)

Light has the potential, then, to be both a wave and a particle. But how do we know when it is which? We know only by observing it. If we choose to observe light by means of the double-slit experiment that Young used, we find that light is a wave. If we choose to observe light by using the photoelectric effect that Einstein used, we find that light is a particle. Though the contradictory wave-like and particle-like characteristics are both true of light (Niels Bohr's complementarity of opposites), at any given time we "make" light be either a wave or a

particle, depending on how we choose to observe it. By selecting one property of light to observe, we simultanecusly obscure the other property. The mutually-exclusive nature of the wave-like and particle-like characteristics of light is a product of out interaction, or rather our transaction, with light (Zukav, 1979, p. 93).

As one can readily see, conclusions like these differ markedly from the viewpoint of classical physics, which we have learned to accept as "commonsense." We have learned to think of objective reality as separate from subjective reality, from mind: things are what they are, regardless of whether or how we observe them. Quantum mechanics, the study of subatomic phenomena, challenges this view. Physicists have discovered that at least in the subatomic realm, a human observer cannot observe or measure anything without affecting its very nature. Or as literary critic David Bleich suggests (1978), "the notion of objectivity is itself only a paradigm" (p. 11). Thus while classical physics spoke of interactions between separate, independently characterizable entities (such as an observer and the observed), modern subatomic physics speaks of transactions between entities that are in some way defined through the act of relating to one another (Dewey and Bentley, 1949, p. 108). Thus particles and waves are events, transactions between observer and observed.

The transaction between "observer" and "observed" results in the so-called "quantum leap," the simultaneous actualization of one possibility and negation of others. For example: when a human observer intervenes to measure some aspect or quality of a particle, such as its position or momentum, the person actualizes one possibility (makes it happen) and collapses all the other possibilities (negates the possibility of their happening). Or as Robert Frost indicates in "The Road Not Taken," if you

take one road, you cannot simultaneously take another. This collapsing of possibilities, then, is the quantum leap. As expressed in Heisenberg's uncertainty principle, the physicist can never predict with absolute certainty which possibility will be actualized and which other(s) will be negated; the physicist can only calculate the probability of certain possibilities being actualized or negated in the transaction that results in the quantum leap.

Largely because of the inseparability of observer and observed, and because of the fundamental nature of the transactional process which unites these two, physicists investigating what they call the "microscopic" aspect of reality typically reject the universality of the mechanistic paradigm and the metaphor of the universe as a clock or a machine. As Einstein (Einstein & Infeld, 1942) said nearly half a century ago, "Science did not succeed in carrying out the mechanical program convincingly, and today no physicist believes in the possibility of its fulfillment" (p. 125). While acknowledging that the mechanistic paradigm has led and will continue to lead to magnificent insights and achievements, such physicists believe that the mechanistic model does not accurately reflect the fundamental nature of the universe. Rather, they suggest that the universe is more like an organism, a process, with no clear separation between subjective and objective, observer and observed, mind and matter.

Thus several of the basic tenets of this organic model offered by quantum physics have, I think, particular relevance for our understanding of the reading process and the literary experience. First, the world cannot be analyzed into separately identifiable parts, elemental "building blocks" that can be recombined to produce the whole. There are two reasons for this. One is that the parts are not separately identifiable; they are

identifiable only in transaction with an "observer," and their very nature is determined by such transactions. A related reason is that the basic parts are not really parts anyway. They are events that persist only momentarily. No sooner do we identify a particle than it typically collides with other particles in its environment, transacting in a burst of energy that annihilates the original particles and creates new ones.

A related tenet of quantum physics is that the fundamental nature of the universe is activity, process. As Whitehead (1925) noted, "nature is a structure of evolving processes. The reality is the process" (p. 106). Zukav (1979) observes that "The search for the ultimate stuff of the universe ends with the discovery that there isn't any" (1979, p. 193). Particles are energy, energy in constant transaction and transformation. Fritjov Capra (1982) explains that "Atoms consist of particles, and these particles are not made of any material stuff. When we observe them we never see any substance; what we observe are dynamic patterns continually changing into one another--the continuous dance of energy" (Capra, 1982, p. 91). Or as Zukav (1979) says, "The subatomic world is a continual dance of recreation and annihilation, of [what appears to be] mass changing to energy and energy changing to mass. Transient forms sparkle in and out of existence creating a never-ending, forever-newly-created reality" (1979, p. 197). "At the subatomic level," Zukav continues, "there is no longer a clear distinction between what is and what happens, between the actor and the action. At the subatomic level the dancer and the dance are one." Thus insofar as the rational mind has been able to determine, the universe is fundamentally "dancing energy" (Zukav, 1979, p. 193).

Thus quantum physics demonstrates the first six of what I have listed as basic tenets of the paradigm emerging in the sciences as well as in other disciplines. The seventh of these tenets, involving

simultaneity and the inseparability of cause and effect, is best supported by Prigogine's theory of dissipative structures, stemming from his research in chemistry. So are the eighth and ninth tenets.

Chemistry and Biology

The phenomenon of synchronicity, wherein cause and effect are inseparable and indeterminate, can most easily be illustrated by what are known in chemistry as "chemical clocks." In his introduction to Prigogine and Stengers' Order Out of Chaos (1984), Toffler uses an analogy to clarify the nature of chemical clocks:

> Imagine a million white ping-pong balls mixed at random with a million black ones, bouncing around chaotically in a tank with a glass window in it. . . .
>
> Now imagine that suddenly the window goes all white, then all black, then all white again, and on and on, changing its color completely at fixed intervals--like a clock ticking.(p. xvi)

In like fashion, molecules under certain conditions seem to be able to transact or "communicate" with each other simultaneously, synchronistically, enabling a new order to arise.

This brings us to Prigogine's theory of dissipative structures, which, by analogy, likewise has relevance to language processing.

Ilya Prigogine has demonstrated that when an "open system," one which exchanges matter and/or energy with its environment, has reached a state of maximum entropy, its molecules are in a state of equilibrium. Spontaneously, small fluctuations can increase in amplitude, bringing the system into a "far-from-equilibrium" state. Perhaps it is the

instability of subatomic "particles" (events) on the microscopic level that causes fluctuations on the so-called macroscopic level of molecules. At any rate, strongly fluctuating molecules in a far-from-equilibrium state are highly unstable. Responding to internal and/or external influences, they may either degenerate into chaos or reorganize at a higher level of complexity. An example would be the molecules in a homogenous solution reorganizing themselves into crystals. Prigogine and Stengers (1984) summarize: "We now know that far from equilibrium, new types of structures may originate spontaneously. In far-from-equilibrium conditions we may have transformation from disorder, from thermal chaos [entropy] into order" (1984, p. 12). From this transformation may originate "New dynamic states of matter" reflecting the transaction of a given system with its surroundings. The new, more complex structures are called dissipative structures because of the role of dissipative processes in their formation (1984, p. 12). It was for this work with dissipative structures that Prigogine received the Nobel Prize in chemistry in 1977.

It appears, then, that organization and hence information arise phoenix-like from the ashes of thermal entropy, as it were (see Campbell, 1982, for a discussion of entropy and information). In a far-from-equilibrium state molecules become sensitive to one another and to their environment (e.g. weak gravitational or electrical fields--Prigogine and Stengers, 1984, p. 14). As indicated, simultaneous "communication" among such sensitive molecules characterizes the aforementioned phenomena of chemical clocks, in which all moledules change together in a rhythmic pattern. Clearly the molecules engage in transactions through which their very nature is (re)determined. According to Prigogine and Stengers, such

communication of molecules in a non-equilibrium state seems to be the rule in biology. "It may in fact be taken as the very basis of the definition of a biological system" (1984, p. 13; see also pp. 14 and 180-181).

Certainly the concept of dissipative structures provides a powerful model for understanding the nature and function of biological, social, or indeed any open system, including language. In fact, the original French edition (1979) of Prigogine and Stengers' Order Out of Chaos aroused quite a furor, stimulating "a marvelous scientific free-for-all among prestigious intellectuals in fields as diverse as entymology and literary criticism" (Toffler's introduction to the English edition, p. xii).

Prigogine's research on the macroscopic chemical and biological level contributes to the emerging paradigm in science in various ways, most notably by reinforcing the notion of process as fundamental; by demonstrating the simultaneity of events (as in the "chemical clock"); and by revealing the transactive nature of communication both horizontally, among molecules, and vertically, between molecules and their environment. In general, it seems clear that molecules are prototypical examples of what Arthur Koestler (1969) called holons (from Greek holos, whole, and -on, meaning particle or part). Hierarchically organized, "Biological holons are self-regulating open systems which display both the autonomous properties of wholes and the dependent properties of parts" (1969, pp. 210-211). They engage in both bottom-up and top-communication as well as horizontal communication with units on the same level.

New Paradigms in Reading and Literary Theory

Reading Theory: Transactions and Schemata

These various theories and concepts from physics, chemistry, and biology complement, or resonate with, key concepts in current reading theory

and literary theory. According to the latter as well as the former, meaning is determined through transactions of various sorts; the whole is not the sum of "parts" which can be separately identified; and there is no sharp separation between the knower and the known. Reality in general, and reading and the literary experience in particular, are viewed as organic processes.

While Albert Einstein began challenging the foundations of classical physics with his discovery that light is a particle as well as a wave, Edmund Huey (1908) was conducting experiments and gathering evidence demonstrating that even with an alphabetic writing system such as ours, a mechanistic "building block" theory of reading is not merely inadequate but inaccurate. He determined, for example, that four-letter and even eight-letter words can be identified almost as rapidly as individual letters, thus suggesting that word identification does not ordinarily proceed from the identification of individual letters. In fact, it appears that letter identification normally proceeds from the identification of words, in fluent reading--though normally, of course, we don't bother to identify letters as we read.

This top-down processing (larger units to smaller) becomes more plausible when we realize that words can be identified under conditions that make it impossible to identify single letters. An example from Frank Smith (1978) is instructive. Suppose one can faintly see two letters: the first is either a or e and the second is either f or t, but one can't see well enough to identify either letter--the letters are too small, or too far away, or the room is too dark. If, however, the person is told that the letters make a common English word, he or she can immediately

identify the word as *at* and then identify the letters as *a* and *t*. One identifies the word *first*, or rather one identifies the word and the letters more or less simultaneouly, having reasoned that *a* + *t* is the only one of the four possible combinations that makes a common English word. Ir this case, the information that the two letters make a common English word stimulates the "quantum leap," the actualizing of the first possibility as *a* and the second as *t* (example from Smith, 1978, p. 125). This quantum leap involves both a vertical transaction, between word and letters, and a horizontal transaction, between the letters themselves.

With the aid of grammatical structure, words are similarly defined in transaction with one another. *Cook the roast*, for example, is not the same as *Roast the cook* (roasting one another being a popular sport among entertainers these days, if not among chefs). In isolation, *cook* and *roast* have potential meanings. Imposing a sentence structure on them provides information about information, actualizing one of their possible meanings and negating others, in a transaction that might again be viewed as a quantum leap. Notice, too, that a word may depend upon following words for its meaning. The word *fire* is not the same in *Fire the cook* as it is in *Fire the furnace*. Similarly, the *tear* in *Chris has a tear in her jeans* is not the same as *tear* in *Chris has a tear in her eye*. The words transact with one another in non-linear fashion, with individual word meanings being determined through such transactions.

But of course it would be vastly oversimple to say that meaning arises merely from a transaction among words. As many socio-psycholinguists, schema theorists, and semioticians have been pointing out, meaning arises in transaction between the words and the person reading them. What the

reader brings to the text is crucial in determining the meaning. The reader brings his or her schemata, the reader's lifetime of knowledge and experience. A schema can be thought of as a gestalt, the whole of which is greater than or different from a collection of its parts or elements (Iran-Nejad, 1980, p. 10). Iran-Nejad and Ortony (1984) explain:

> Each element loses its identity and becomes an integrated part of the combination in the same way that, when oxygen and hydrogen combine to produce water, the properties of these elements are no longer evident. Furthermore, the resultant structure comes to possess emergent properties that are not present in any of the component elements in the same way that water possesses properties not possessed by its component elements. (p. 14)

Though many cognitive psychologists think of schemata as relatively fixed mental structures (e.g. Rumelhart, 1980), others consider them as transitory as the physicist's particle. Bartlett (1932), for example, in first adopting the term schema, insisted that a schema was a functional rather than a structural concept (e.g. Bartlett, 1932, Ch. 10 and p. 304). Ulric Neisser (1976) indicates that a cognitive schema is "a momentary state of the perceiver's nervous system" (1976, p. 181), though of course "old" schemata are constantly reactivated in response to incoming information. Taking the comments of Bartlett much further, Iran-Nejad and Ortony (1984) have developed a biofunctional model that attempts to explain the possible neurophysiological bases of such "transitory dynamic structures" (schemata) and how they are activated, as well as how new experience and information are related to old and therefore easily reactivated schemata.

Thus transitory to begin with, it is hypothesized, schemata are constantly changing, since the conscious individual is in continual transaction with the external world. As Bartlett puts it, "The schemata are, we are told, living, constantly developing, affected by every bit of incoming sensational experience of a given kind. The storehouse notion is as far removed from this as it well could be" (Bartlett, 1932, p. 200). In fact, Iran-Nejad and Ortony suggest that not only is the "storehouse" notion inaccurate, but so is the notion of separate mental entities, cognitive building blocks (1984, p. 53). Meaning, then, is not a product but a process, the continuous process of transaction between the individual and the environment, between old schemata and new.

Before returning to how meaning arises in the reading process and in literary experience, I would like to mention that not only in reading but in reading research itself, the concept of transaction is crucial, from a socio-psycholinguistic, semiotic perspective. Harste, Woodward, and Burke (1984) point out that data do not exist "out there," ready to be compiled; rather, data "constitute the results of a transaction which occurs when teacher or researcher meets child" (1984, p. 84). These researchers contrast the mechanistic experimental approach, which assumes the world is made up of independently identifiable and separately manipulable variables, with the organic ethnographic approach, which denies the existence of separately identifiable and manipulable variables. According to the latter view, "the things experimentalists call 'variables' in an instance of language transact to form a new phenomenon, the sub-components of which are not reducible" (1984, p. 88). In other words, the observer inevitably affects what is observed. (See also Deely, 1982, pp. 96, 98-99, 115.)

Harste, Woodward, and Burke (1984) summarize four of the points crucial to an ethnographic world view in general and a semiotic perspective on reading in particular:

1. The parts of the event do not equal the event itself.
2. The parts of the event form an irreducible whole.
3. The parts of the event transact to form a whole greater than the sum of parts.
4. If the individual parts are manipulated, the whole is destroyed. (p. 89)

Clearly, then, meaning arises through the process of transaction. In a sense, meaning is that transaction, that process.

Literary Theory: Transactions and Quantum Leaps

In discussing literary theory I shall, with one exception, omit mention of the European critics like phenomenologist Roman Ingarden, hermeneuticist Hans-Georg Gadamer, and deconstructionist Jacques Derrida.

In modern American literary theory, then, the beginnings of the notion that meaning is an event, a transaction, a process, can be found in Louise Rosenblatt's Literature as Exploration (1938), where she indicates that a literary work is a transaction between reader and text (p. 21, n. 1). Rosenblatt clarifies this concept in The Reader, the Text, the Poem (1978). She explains that the Text itself is the word-symbols and patterns created by the writer; it is not yet a literary work. During the reading of the text, the transaction between Reader and Text, the reader's schemata are modified and the Poem (by which Rosenblatt means any literary work) is

simultaneously created. Rosenblatt elaborates on what Vygotsky (1962, 1978) might see as this creative transaction between thought and language:

> The poem, then, must be thought of as an event in time. It is not an object or an ideal entity. It happens during a coming-together, a compenetration, of a reader and a text. The reader brings to the text his past experience and present personality. Under the magnetism of the ordered symbols of the text, he marshalls his resources and crystallizes out from the stuff of memory, thought, and feeling a new order, a new experience, which he sees as the poem. This becomes part of the ongoing stream of his life experience, to be reflected on from any angle important to him as a human being. (Rosenblatt, 1978, p. 12)

Agreeing that a Poem is an event, response theorist Stanley Fish (1980) says "Interpretation is not the art of construing but the art of constructing. Interpreters do not decode poems; they make them" (Fish, 1980, p. 327).

By whatever name, this transactional model of the literary experience is shared by others, notably Wolfgang Iser in The Act of Reading (1978) and Norman Holland in 5 Readers Reading (1975). Iser speaks of the "work" as being located somewhere between text and reader, actualized as a result of the interaction [transaction] between the two. The reader receives the message by composing it; therefore, the "division between subject and object no longer applies, and it . . . follows that meaning is no longer an object to be defined, but is an effect to be experienced" (Iser, 1978, p. 10). Meaning is a happening, an event (pp. 21, 67-68). Sounding much like the biologists and physicists, Iser speaks of the relationship between reader and text as being a kind of self-regulating system (p. 67) and suggests

that the literary text itself is a system "which shares the characteristics of other systems as it brings out dominant meanings against a background of neutralized and negated possibilities" (Iser, 1978, pp. 71-72).

Despite his insistence on the breakdown of the subject-object dichotomy, Iser speaks of the structure, the schemata, within the text itself (pp. 141, 143, 227). Holland (1975) goes further in rejecting the subject-object duality: "A reader reads something, certainly, but if one cannot separate his 'subjective' response from its 'objective' basis, there seems no way to find out what that 'something' is in any impersonal sense" (1975, p. 40). While placing more emphasis on the psychological predispositions and processes of the reader then either Rosenblatt or Iser, Holland characterizes the role of literary criticism in terms reminiscent of both. He advocates a "transactive criticism" that "takes as its subject matter, not a text, but the transaction between a reader and a text" (p. 248). David Bleich in Subjective Criticism (1978) goes even further, rejecting the objective existence of the text almost entirely; for example, he criticizes Holland for being too "objective" in considering the text and reader as separate entities that transact with each other (1978, p. 114; see also pp. 101, 109, 111). Bleich (1978) suggests: "The most that a reader can do with the real object, the text, is to see it . . . . discussion of the work must refer to the subjective syntheses of the reader and not to the reader's interaction with the text" (p. 111).

It should be noted that both Rosenblatt (1978, e.g. p. 144) and Iser (1978, e.g. p. 68) make explicit references to parallels between their literary theories and modern science, while Bleich (1978) discusses alternative paradigms in his introductory chapter "The Subjective Paradigm" and Holland (1975) discusses some interesting implications for literary theory in his final chapter, "Knowing."

Borrowing terminology from the physicist David Bohm (1980), we might say that in the view of all of these theorists, the Poem, as Rosenblatt defines it, is implicate in the collocation of reader and text. The Poem is made explicate, is actualized, during the transaction between the two. In effect, the reader triggers a quantum leap: by interpreting the text in a particular way, by actualizing one particular "Poem," the reader simultaneously negates, for that moment in space/time, all other possible "Poems."

The qualification "for that moment in space/time" is crucial, for reading always takes place in a context, as both reading theorists and literary response theorists have been emphasizing lately. (See, for example, Harste, Woodward, and Burke, 1984, and Fish, 1980). In a recent paper, Elizabeth Flynn recommends a synthesis of approaches that reflect a concern for the objective, for what the text contributes, as exemplified in Wolfgang Iser's The Act of Reading (1978); a concern for the subjective, for what the reader contributes, as exemplified in David Bleich's Subjective Criticism (1978) and Norman Holland's 5 Readers Reading (1975); a concern for the transaction between reader and text, as expressed by Rosenblatt in The Reader, the Text, the Poem (1978); and a concern for context, for what the total reading situation contributes, as exemplified in the later essays in Stanley Fish's Is There a Text in this Class? (1980).

Stanley Fish (1980) suggests a three-way transaction among reader, text, and context: "This [his previous statement] does not mean that the context comes first and that once it has been identified the construing of sense can begin. . . . the two actions (the identification of context and the making of sense) occur simultaneously" (1980, p. 313). And again, "text, context, and interpretation all emerge together" (1980, p. 340). As long

as one views the transactions as more or less simultaneous, one might conceptualize transactions within transactions, reader and text transacting with one another, and both transacting, independently and also together, with the context (situational, social, etc.) in which the reading act takes place. That is, one might consider the relationship between reader, text, and context to be a hierarchy, multi-directional, with some transactions occurring within others. Better yet, one might abandon the term "hierarchy," which erroneously suggests exclusive top-down processing (see Capra, 1982, pp. 280-282), in favor of Koestler's term "holarchy." A holarchy is a hierarchically arranged, open system of holons, with "countless feedback loops and flexible strategies" (Hampden-Turner, 1981, p. 162). Surely some such system as a holarchy must be postulated in order to account for the multi-directional transactions that occur in the literary experience.

Reading Theory Again: Top-down and Bottom-up Processing

Of course within the reader-text transaction itself, there is also a holarchy of transactions. Letters are defined in nonlinear transaction with one another, words are defined in nonlinear transaction with each other, and so forth, on up to the level of texts. However, there is also a constant interplay between and among levels, with the processing being as much or more top-down (schema to words or letters) as bottom-up (letters or words to schema). That is, there is simultaneous intra- and inter-level processing, with each level potentially affecting all other levels at virtually the same time. (See Campbell, 1982, Ch. 18 "The Top and Bottom of Memory," for a recent non-technical discussion of related ideas.)

The top-down nature of processing, and the fact that the visual display constitutes only a small fraction of the information available to readers, can be nicely illustrated with examples from Anthony Burgess's novel A Clockwork Orange (1962). Out of context, it is difficult if not impossible to determine the meanings of the seeming nonsense words deng, tolchock, veck, and viddy, taken from the first two pages of the novel. It is difficult even to determine their parts of speech. Here, however, the words are used in a clarifying context: "Our pockets were full of deng, so there was no real need . . . to tolchock some old veck in an alley and viddy him swim in his blood while we counted the takings . . . ." (Clockwork Orange, 1962, pp. 1-2). In context, we can easily use preceding and following syntax to determine each "new" word's part of speech, and semantic context to make a reasonable prediction as to its meaning. We bring to bear our internalized knowledge of grammar and the cognitive schemata developed through experience, both of which are reactivated as we read. Thus in reading there normally are transactions between and among contexts: the context of the evolving surface structure, the context of the text world, the context of the reader, and the context of situation.

The importance of context and the top-down nature of language processing are further illustrated by studies investigating the influence of one's activated schemata, one's current mind-set, upon what is understood and what is retained. For example: it makes a considerable difference whether or not subjects know that the passage they have been asked to read is about "washing clothes" (Bransford & Johnson, 1972), whether they know that what they are reading is about shopping at a supermarket as opposed to eating in a fancy restaurant (Anderson, Spiro, & Anderson, 1977), buying as opposed to burglarizing a home (Anderson & Pichert, 1978), or

wrestling as opposed to breaking out of jail (Anderson, Reynolds, Schallert, & Goetz, 1977).

Clearly, then, the visual display is only a tiny fraction of the information available to a reader. Much of language processing proceeds top-down, from schemata to words (and, if we should so choose, letters), with each level more or less simultaneously affecting all the levels below it. For example, reactivating a reader's (or listener's) previously developed schemata facilitates the identification of propositions (chunks of meaning) and clauses (significant grammatical units) in the text, while also facilitating the identification of words (and letters), all more or less simultaneously. Even the mere "perception" of words is clearly a cognitive act, facilitated by comprehension.

To the extent that comprehension is also, simultaneously, bottom-up, there are interesting parallels between the language comprehension process and Prigogine's theory of dissipative structures. Insofar as we process language from the bottom up, letters give way to words (if indeed letters are identified), words give way to the propositions expressed in clauses, and propositions are either lost or somehow integrated with our existing cognitive schemata. Koestler (1969) offers a succinct example of how the spoken word resolves itself into increasingly higher-level dissipative structures for the listener, just as the written word does for the reader:

> You watch a television play. The exact words of each actor are forgotten by the time he speaks his next line, and only their meaning remains; the next morning you can only remember the sequence of scenes which constituted the story; after a month, all you remember is that it was about a gangster on the run or about two men and a woman on a desert island. (1969, p. 201)

In a few months you may not remember the movie at all, yet it has somehow affected your available gangster-movie schema or your love-triangle schema.

Since short term memory can hold only about seven chunks of information, plus or minus two (Miller, 1956), when that limit is reached, it is not surprising that the information must be reorganized at a higher level or be lost. To use Prigogine's terms, the fluctuations have become sufficiently great that the system must either degenerate into chaos or reorganize itself at a higher level. The analogy is by no means perfect, of course: in this case the system simultaneously degenerates into chaos and reorganizes itself at a higher level, for some information is lost (the precise letters, words) as other information (meaning) is successively reorganized. Nevertheless, the analogy holds fairly well.

Notice, too, the relevance of Prigogine and Stengers' observations about the transactive communication among molecules and their environment, which they claim to be the very basis of a biological system. Just as molecules in a far-from-equilibrium state "communicate" or transact with one another horizontally and transact with their environment vertically, so language units nearing the limits of short term memory (if not before) communicate or transact with one another horizontally and with their language environment vertically. Like molecules, the units on each level are what Koestler (1969) calls holons. Because of their vertical transactions, they have the autonomous property of wholes and the dependent properties of parts (Koestler, 1969, pp. 210-211). They are part of an exceedingly complex, multi-directional and multi-dimensional communication holarchy.

Thus concepts from science parallel and at least to that degree reinforce a model of language processing that is characterized by

simultaneous transactions among units on the same level, by simultaneous top-down and bottom-up transactions, and via the bottom-up transactions, by increasingly more comprehensive "dissipative" structures. The language units themselves--words, for example--are transitory "events" that exist only momentarily, before being replaced by units on a higher or "deeper" level. Jantsch (1980) generalizes about systems like language: "In the domain of self-organizing systems, information is also capable of organizing itself; new knowledge arises" (p. 11).

Conclusion

Summary of Parallels Between Science and Reading and Literary Theories

In summary, then, there are various ways in which the paradigm emerging in science, particularly quantum physics, chemistry, and biology, parallels a paradigm emerging in reading and literary theory. Perhaps most basically, they share an emphasis on organicism and process, specifically the process of transaction between interdependent entities. Thus these emerging paradigms assert such revolutionary concepts as the following:

1. Reality is fundamentally an organic process.
2. There is no sharp separation between observer and observed, reader and text, reader/text and context.
3. The whole (universe, sentence, text, etc.) is not merely the sum of parts which can be separately identified.
4. Meaning is determined through transactions (between observer and observed, reader and text, reader/text and context, and among textual elements on and across various levels).

Clearly this organic view is in sharp contrast to the mechanistic model which is so widely accepted. As Whitehead (1925) noted over half a century ago, "scientific theory is outrunning [has outrun] common sense" (p. 166). Or to put it another way, we might conclude, with Zukav (1979), that "our commonsense ideas about the world are profoundly deficient" (p. 300).

These parallels between science and reading/literary theory can be viewed as contributing to the humanistic General Systems Theory pioneered by biologist Ludwig von Bertalanffy. A system, according to Bertalanffy, is any entity maintained by the transaction of its parts; thus the fundamental reality is the organized relationship of parts, not the parts themselves (Davidson, 1983, pp. 25, 27, 28). Thus, of course, each level of language and language processing (letters, words, etc.) is a system, so with language and language processing we have systems within systems within systems, holarchically and thus multi-directionally interrelated.

In any case, General Systems Theory is not a theory, really, but an approach to comprehending reality, based upon the assumption that theories of any kind, whether physical, biological, psychological, or social, operate in accordance with the same fundamental principles. General systems theory is, then, a search for these common principles, a general system of principles such as those offered above. Together, such principles begin to shape a cross-disciplinary paradigm that is exemplified in other fields as well, ecology and holistic medicine being two of the most notable (see, for example, Capra, 1982).

A New Metaphor: The Dance

I'd like to close by returning to the dance metaphor adopted by certain quantum physicists. Just as the universe may be viewed as

fundamentally a dance of transient forms that sparkle in and out of existence, so meaning, the Poem, may be viewed as an ever-fluctuating dance that occurs more or less simultaneously on and across various levels: letters, words, sentences, schemata; writer, text, and reader; text/reader and context; the present reader with other readers, past and present; and so forth; all connected in a multi-dimensional holarchy, an interlocking network or web of meaning, a synchronous dance in which there is no clear distinction between what is and what happens. As Rosenblatt (1966, p. 1000) has noted, Yeats expressed it well in "Among School Children":

> O body swayed to music, O brightening glance,
> How can we know the dancer from the dance?

It is worth noting, I think, that a metaphor is more than a convenient way to visualize something. As Lakoff and Johnson (1980) point out, cultural change may be brought about in part by replacement of old metaphorical concepts with new ones (1980, p. 144). Metaphors, models, and paradigms are an important means of structuring our conceptual system, and our conceptual system in turn affects how we perceive reality.

Dominating Western thought for the last three centuries, the mechanistic metaphor and model have served as a prism, showing us new colors, enabling us to better analyze and thereby understand, predict, and control much of our world. But the mechanistic paradigm is also a prison in which we have unwittingly become prisoners (Zukav, 1979, p. 200), a prison which has prevented us from understanding other aspects of our world.

In order not to become a similar prison, the organic paradigm toward which we are moving must include mechanism, must somehow transcend the simplistic dichotomy I have been describing and demonstrate the ways in which both mechanism and organicism are simultaneously true. This, of course, is what physicists themselves have done: with the advent of relativity theory and quantum mechanics, physicists have replaced the mechanistic model of the universe with an organic model, while still acknowledging that mechanism appears to be the best explanation for many aspects of reality. The universe itself is seen as fundamentally an organic process within which mechanism operates.

Such inclusiveness can be attributed to the theory or "world hypothesis" of organicism itself, according to Pepper (1942). He sees as a basic tenet of organicism the assumption that necessarily limited paradigms will inevitably be replaced by more inclusive paradigms that incorporate both the old and the new. This incorporation is not a synthesis in which both lose their identity but rather a larger vision in which both are seen as necessary complements to one another, each valid in its own realm and its own way. As the physicist Niels Bohr implies, the universe is characterized by the necessary complementarity of opposites. Both organicism and mechanism are necessary dancers in the universal dance.

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